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ABSTRACT

In this study, which examines the relationship between level of information processing and level of general socialization, a total of 90 children aged 11 and 14 years and a group of 17 adults were presented with an organizational problem: how to order simultaneously presented tasks. Subjects were individually shown a map with locations and distances marked on face-down content and time-distance cards and asked to organize the performance of several tasks which had specific time constraints. Problem solving behavior was recorded by monitoring selection of cards, chosen sequences of moves on the map, and verbal comments. Data was analyzed first by testing 3 hypotheses derived from Schroder's construct of conceptual complexity. Each hypothesis was supported showing that with increasing age there are increases in level of proving time components of the task, in branching procedures and in the number of correct solutions. Second, the social background of the task was taken into account and hypotheses derived from this theoretical position discussed in terms of the data which confirms theoretical assumptions about the influence of level of general socialization on actual problem solving behavior. The problem was then transformed into a domino-type game and presented individually to a total of 45 subjects in age groups 11 years, 14 years, and adult. Results showed that adults need more time for solving the domino-type task but that younger groups need less time and produce more correct solutions than on the organization problems. (GO)

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Developmental changes in problem solving as a function of level of socialization. [1)]

by Rolf OERTER, Eva DREHER and Michael DREHER

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Introduction

Most of the research in problem solving is concerned with clearly structured problems which consist of a few elements or dimensions. The problems usually have isolated contents and avoid associations to complex experiences in every-day life.
The reasons for this strategy are well known. An exact experimental design demands control over all conditions and systematic variation of the conditions. Problem solving of complex tasks is very hard to analyse and the determinants of the result often remain ambiguous. If a problem is embedded in complex social relations, one cannot discern between determinants of 'pure' problem solving processes, for example logical inference, and determinants of preceeding experiences which had been storaged by the subject before and are actually used during the process of thinking.

However some authors, dissatisfied with this state of affairs, have reflected that solving clearly structured problems with a few elements cannot be easily compared with solving complex problems which consists of a large number of elements or dimensions. SCHRODER et al. (1967) have described a level of information processing which they call information processing capacity (IPC). They view IPC as a function of environmental complexity (EC) and integrative complexity of personal properties (CPP):

$$IPC = f(EC, CPP)$$

The authors also distinguish explicitly between <u>what</u> is thought and <u>how</u> is thought. Moreover, their levels of cognitive complexity are well known. HARVEY, HUNT & SCHRODER (1961), for example,

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1) This paper presents preliminary results which are a part of a series of studies about cognitive socialization. The theoretical framework of our research could not be described here in detail. Only a few theoretical aspects necessary for comprehension are included in this report.

used them to describe structure of beliefs and personality organization.

Another bulk of research is concerned with role-learning which seems to be a paradigm for solving complex problems. This is the case because in role-learning and role-taking structuring of complex relationships between a big number of elements are involved. FLAVELL (1968) studied such processes with respect to a theory of socialization.

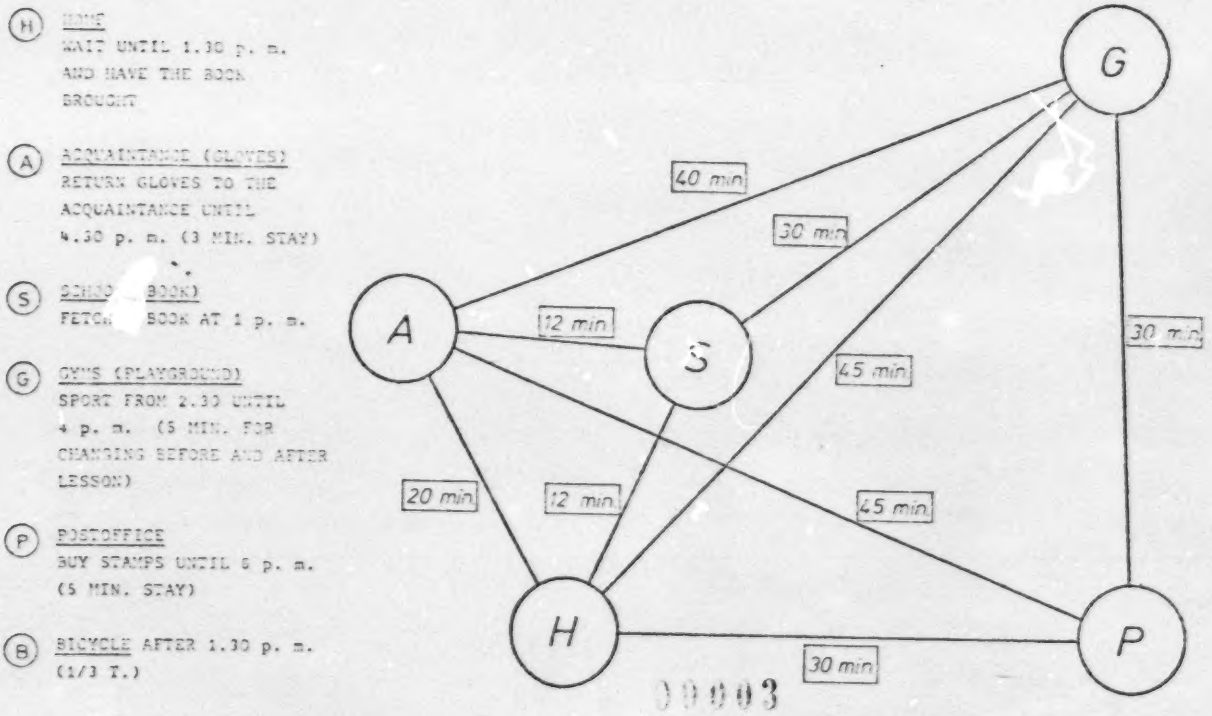
Following this intention the development of problem solving capacity in maintaining complex social situations in every-day life becomes a question of special interest.

The purpose of this paper is to analyse problem solving behavior in complex tasks which represent behavior in every day social situations. We hope to find the relationships between the level of information processing on the one side and the level of general socialization as well as the special capacity in cognitive development (e. g. the stages of thinking sensu PIAGET) on the other side.

An organization problem

Now I shall present an organization task which is an example of the type of task we have used in the first study.

Figure 1: Plan of the organization task



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The problem consisted of how to order simultaneously presented tasks. This tasks were to be carried out at different places with various time limits.
The tasks involved:
Returning gloves to an acquaintance (location: acquaintance; time limit: 4.30 p. m. including 3 min. stay), fetching a book from one's friend (location: school; time limit: 1 o'clock p. m.), playing sports for one and a half hours (location: play-ground; time limits: from 2.30 p. m. until 4 p. m., including 5 min. for changing before and after playing), and buying stamps (location: post office; time limit: 6 o'clock p. m. including 5 min. stay).

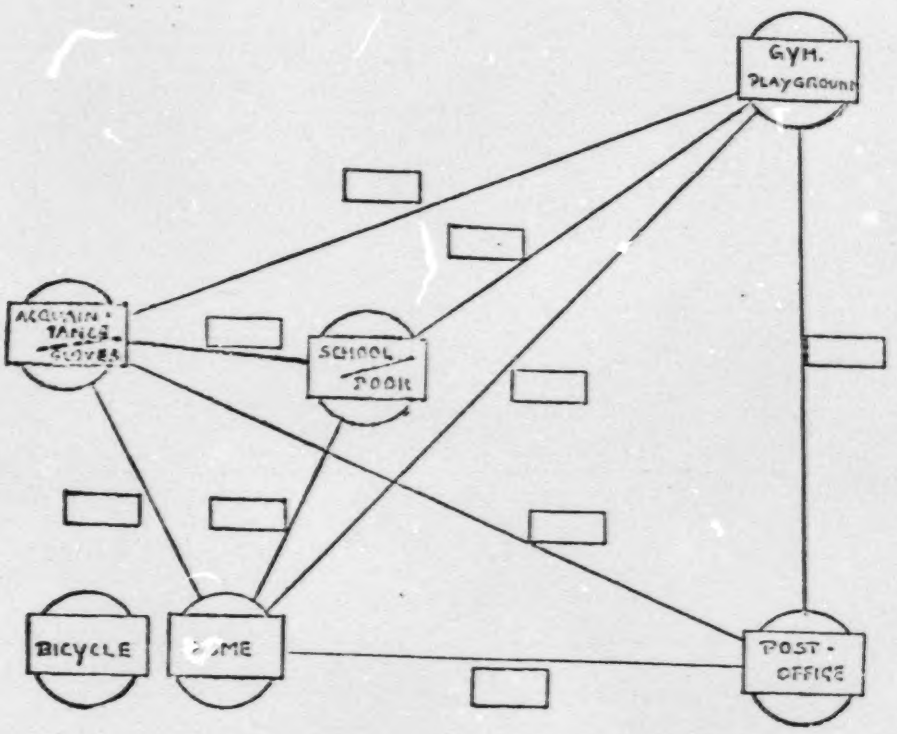
Distances between the different places were expressed as time distances, for example 20 min. from 'home' to 'acquaintance'. Two further conditions were introduced. First one could stay at home until one's friend brought the book. In this case the friend would arrive at 1.30 p. m. at the latest. Second one could use the bicycle after 1.30 p. m., when th parents who had the key to the bicycle returned. By using the bicycle, only one third of the time that was spent for walking would be regarded.

Method

Materials. The subject was presented with a map (60 cm x 90 cm) which contained the places (home, school etc.) and the routes (figure 2). Further information was given on cards which were covered on the map. There are two types of cards. The first type of card contained job description including the certain place where the job was to be done and the time limits within which the job was to be finished. These cards lay near the points of the map marking the places. In the following they are called content-cards . The second type of card contained information about the time which was required to walk from one place to another. These cards lay covered near the lines representing the routes (figure 2). In the following they are called time-distance-

cards. Near the card 'home' lay the card 'bicycle' which contained the information about using the bicycle after 1.30 p. m.

Figure 2: Materials presented with the organization problem



The subject was told that the boy had to perform several tasks during the afternoon and that all tasks should be finished within the given time. Having read all information about the tasks, the subject began to solve the problem. He could lift up the cards as often as he liked but only one card at a time, so that the experimenter was able to register the steps selected by the subject.

Recording. The experimenter recorded the reactions of the subject on sheets which were prepared in a specific manner for the experiment. Verbal comments were also recorded. For each person the information obtained about problem solving behavior was ordered and transformed into a structure from which the important features of individual strategies could be inferred. Figures 3 to 5 present several examples of the structured record of problem solving behavior.

Figure 3: Examples of recorded problem solving behavior; Subject A

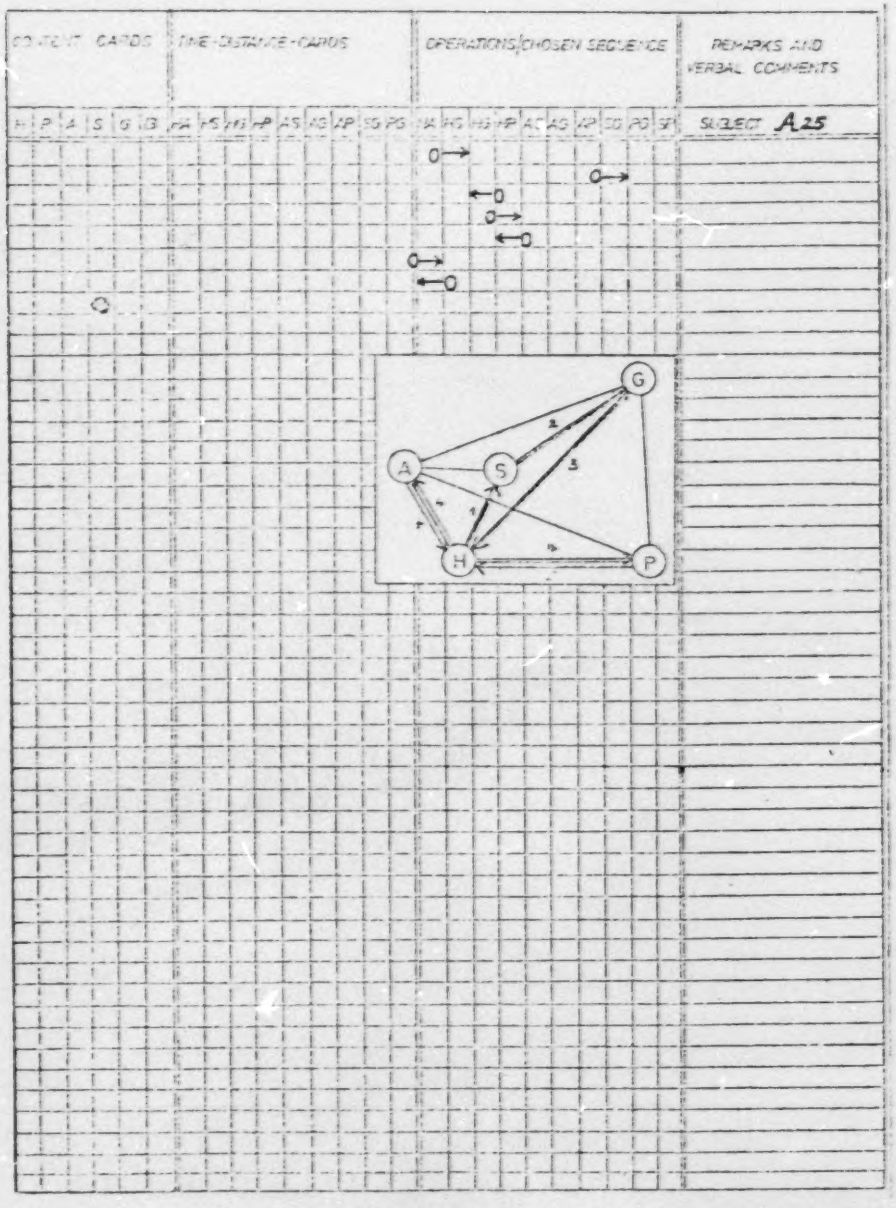


Figure 4: Examples of recorded problem solving behavior: Subject B

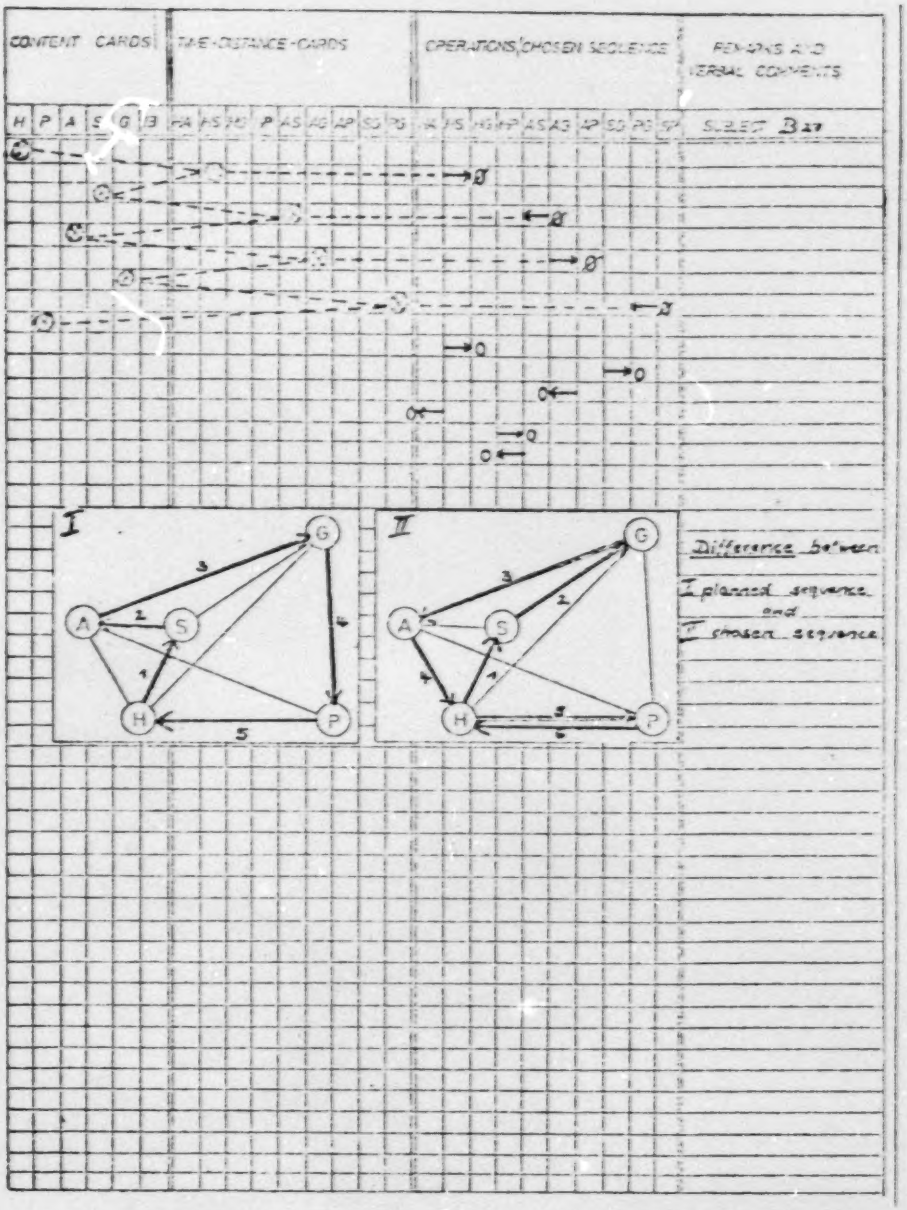


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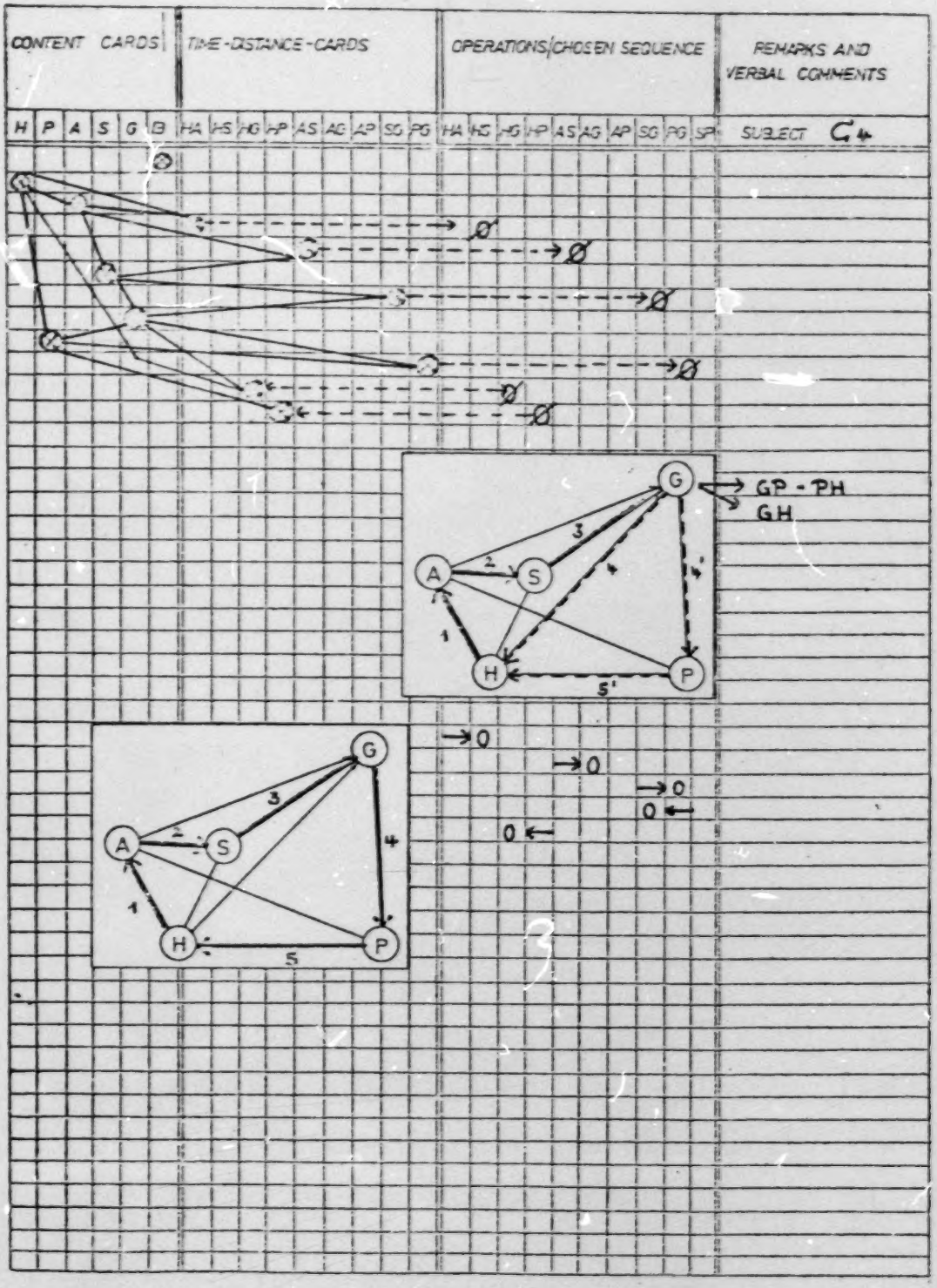
Figure 5: Examples of recorded problem solving behavior: Subject C



Remarks: In the first column the sequence of cards containing information about task content and points of time is recorded from first to last line. The second column contains the sequence of chosen time-distance-cards. The third column presents the actually chosen routes as well as planned routes, for example branching procedures. Verbal remarks of the subject are recorded in the last column. For better illustration, the complete sequence of chosen routes and chosen points respectively is given on a small plan.

As it is easily to be seen, subject A didn't use information cards at all but chose immediately the routes neglecting time limits and all other dimensions of the task.
Subject B contrarily proves all steps in using information about the time limit at the first point, the time necessary for reaching the next point, and the time limit at the second point. He uses the bicycle for performing the last three tasks. Subject C seems to have a complete plan before producing his solution. He takes time-distance-cards and content-cards alternately, following a pathway which lies within the given time limits. But his final solution deviates from his plan and transgresses time limits.

Subjects and procedure. 45 eleven-year-olds and 45 fourteen-year-olds were run individually. 17 adults (university students) served as a control-group. In all groups approximately half of the subjects were males and half females. The subject sat before the map (figure 2) and was introduced to the task. After he had read all single tasks and their time limits as a whole, the experimenter showed him the covered content-cards and the time-distance-cards and told him to take only one card at a time. Finally the subject was told again that all tasks were to be performed within the given time limits.

The organization task as a 'pure' thinking problem

There are two main ways to analyse the organization task with respect to developmental changes in problem solving. The first one uses categories or concepts of formal processes in problem

solving. If we regard the relative complexity of the organization problem, it is obvious that we should use a system or model which adequately describes the forms of information processing involved here. Therefore we shall begin with the construct of 'conceptual complexity' by SCHRODER et al. (1962, 1967, 1971).

The second way of analysing the organization problem reflects the social context of the task. Here the question of interest is whether there exist relations between the general level of socialization and the actual problem solving behavior.

Analysis of the organization problem

Let us turn to the first form of analysis. The model of information processing in the work of SCHRODER et al. discerns between two components: perception and organization of information. Information input is determined by a 'set of filters' which can be described in more detail by the processes of 'differentiation' and 'discrimination'. While 'differentiation' mainly refers to discerning dimensions, 'discrimination' assigns the single dimensions or attributes a scale value. The second part of information processing is understood as the organization of the perceived information. It mainly consists of the combination and integration of differentially scaled dimensions. It is not possible to describe in detail the different levels of conceptual complexity which are related to the above thinking problem. Presently we shall only refer to the dimensions involved in the task and the kind of combination which is necessary to solve the problem. Subject A represented in figure 3 used only one global dimension: 'performing tasks'. He neglected most of the other conditions of the problem. His level of conceptual complexity could be labeled as concrete and simple. The global dimension 'performing tasks' can be differentiated in 'location' or 'place', 'points of time', 'route distance', 'time-distance', 'task', 'stay', and 'reduced time-distance' (by using the bicycle). The main process of differentiation, discrimination,

and integration of information in this problem consists in selecting dimensions of time after having discerned between the above mentioned dimensions, and combining them to the concept of time. All that the subject has to do is to prove whether the given time distance fits between to points of time.

$$P_1 \xrightarrow{\quad t \quad} P_2$$

The combination of points of time and distances of time to a concept of time is the unit for solving the problem adequately. The corresponding trait of information processing consists of equalizing the different tasks to be done at different points. If we take the problem as an academic thinking problem, different tasks and different places are all equal. Their social value or social importance must be neglected.
Until this time we attended to vertical information processes. We also could assume horizontal processes. They refer to the necessity of producing a sequence of the single tasks which fits the given time limits. A very simple method of gaining a sequence is to go from one point to the other without proving any condition. We find this method in the diagram of subject A. A very common strategy consists in branching at a certain point and testing several routes. Finally the subject could develop a complete plan before actually operating.

Hypotheses.

In terms of horizontal and vertical processes we might propose two simple assumptions:

(1) The level of proving time components of the task will rise as a function of cognitive development. The proving procedure can be inferred from the sequence of lifted cards.

(2) Branching procedures or planning behavior in forming a task sequence will be observed more often in older subjects than in younger ones. These horizontal processes can be inferred from the individual's record of problem solving behavior.

A third assumption refers to the results of problem solving:

(3) The number of 'correct' solutions will increase with age. The word 'correct' means that the chosen sequence does not exceed the given time limits.

Results.

As it is seen in tables 1 to 3, the three assumptions are clearly confirmed. Let's turn to the first assumption. At the lowest level the content-cards or time-distance-cards are taken without any combination. For example a subject of this level only lifts up content-cards without regarding time distances. On the second level the subject takes a content-card first and then a time-distance-card (Pt). But he doesn't use the next point of time as a proving element. So he combines points of time and distances of time additively. On the third level we find the adequate combination of points and distances whereby the time distance is put between two points of time. The order of lifting up cards in this case is often the following: first content-card, the next content-card, the corresponding time-distance-card. There is a clear change in the frequency of observed level of proving with age. Older subjects use higher proving levels than younger ones.

Table 1. Developmental changes in proving time components

age	11	14	adults
one or two dimensions, no combination	22 (49)	13 (29)	0 (0)
additive combination (P t)	19 (42)	20 (44)	2 (12)
integrative combination (P t P)	4 (9)	12 (27)	15 (88)
total	45 (100)	45 (100)	17 (100)

Per cent in brackets;

P: Point of time; t: time distance

$\chi^2 = 40.27$ s. ($p < .001$)

Branching procedures are also more often found in higher ages as it is seen in table 2.

Table 2. Developmental changes in branching procedures

age	11	14	adults
branching or planning	16 (36)	22 (49)	11 (65)
no branching	29 (64)	23 (51)	6 (35)
total	45 (100)	45 (100)	17 (100)

Per cent in brackets

comparison 11/adults:

$\chi^2 = 4.52$ s. ($p < .05$)

Somewhat astonishing is the low number of correct solutions by eleven year old subjects and even by the next age-group (Table 3). This result could not be expected in so far as the concept of time which is necessary for solving the organization problem is developed much earlier.

Table 3. Developmental changes in the number of 'correct' solutions (regarding time limits)

age	11	14	adults
solutions within time limits	13 (29)	26 (58)	17 (100)
solutions without regarding time limits	32 (71)	19 (42)	0 (0)
total	45 (100)	45 (100)	17 (100)

Per cent in brackets

$\chi^2 = 25.39$ s. ($p < .001$)

There are still other reasons that the analysis presented above doesn't suffice. Subjects did not often perceive the problem as a task of time planning, but differentiated the kind of task to be done. For example, when they arrived much too early at the play-ground, they argued that they could play with their friends. Coming too late to the acquaintance was compensated by putting the gloves into the mail-box. Therefore it seems necessary to continue with a supplementary form of analysis.

The organization problem as representative of social structures

Problem solving behavior in our task could not be fully explained by 'pure' formal processes of thinking. Experiences of every-day life are involved and largely determine which dimensions are discerned or selected. The social background of the task forms the meaningful structure of task-elements. While in many other studies these factors were eliminated because they seem to remain uncontrolled, we used them explicitly as actual important conditions of socialization. It seems to us that cognitive development cannot be described adequately by means of isolated structures which are purged from central experiences made during socialization.

In the following only one aspect of the social context of the task can be discussed. It is the special relationship of the developing person to his environment when he performs tasks or achieves given goals.

In a preliminary discussion one could postulate several stages or levels during socialization concerning the gradually internalization of the objective structure of labour in our society.

(1) On the first level there is no separation of person and task. Action and the result of action are not differentiated, they are integrated events in the stream of experiences made by the individual. This level is well known as the lack of mediating processes between input and output and as missing in constructing objects.

(2) At an early age, however, we first observe a separation of activity and result of the activity. For example, the child who has played before without regarding the outcome now attends to the result of his play. He finds a name for his drawing or his creations of plastilin. Later the result is anticipated and activities are planned in order to perform the result.
(3) On the next level the child is able to represent several tasks and to bring them in a rank order according to their valences. The most important or most attractive task is performed first. The developmental progress consists in disposing of several possibilities of acting and in the chance to bring them into a new order according to their valence.
This level is relevant for our task because it was observed that subject formed sequences of tasks which somehow seemed to represent a rank order of valences.
(4) The next level is characterized by the ability to separate the task from its valence. In every-day planning it becomes important to perform a task when it is opportune. Maybe a task is of low valence at the present time but must be started in order to finish it in time. On the other hand an important work can be done later on and unimportant activities may be performed at once because now there is opportunity for them. In our organization problem changing rank order becomes relevant when the subject recognize that a task of low valence, such as returning gloves to an acquaintance, should be done before tasks of high valence, e. g. playing sports.
(5) On this level the person separates the task from the effort connected with the task. It becomes unimportant whether the result is carried out with high or low effort. On the contrary the social norm in the world of labour is to gain results or effects with minimal effort. The use of machines and tools is the best demonstration of this norm. In our organization problem the effort of the task mainly consists of completing the distances between the points of the tasks. The subject who wants to perform

with the least possible effort will use the bicycle or he will choose a sequence with the distance being as short as possible. (6) The last level to be discussed here is characterized by the abstraction of the task from the performing person. Now it becomes unimportant whether the subject himself or someone else finishes the task. In the economic area the worker is interchangeable. Generally it is of no interest who has performed a task but the outcome itself is important. In our organization problem there is one condition which refers to this level. The subject could wait and have the book brought. His friend finishes the task and the subject himself has gained time for other purposes.

Summarizing the development described here, we can comprehend this process as a special kind of object formation. The result of a task or work as objective part of the working process is gradually separated from subjective components consisting in the activities of the person. This separation is also a part of decreasing egocentrism which is seen by PIAGET as a main trend of cognitive development. Before we draw conclusions from this postulated developmental process, we have to attend to another aspect of cognitive socialization which refers to the development of time concept within the social context of labour. Remember that in the first analysis there were only a few correct solutions in the group of eleven-year-olds. That means that the subjects did not use the concept of time even though they had it. Therefore we may consider some further conditions concerning the social norm of time. In short three stages of integration of the time concept into labour may be discerned.

(1) Time is irrelevant in the field of perception and action. Tasks are performed without regarding aspects of time. The child does not worry about the time he spends doing things, which is a general source of conflict between parents and children.
(2) Time becomes important for the task. Work has to be done within certain time limits. Obviously this change is due to conditions of school education. On this level the subject would

regard time limits in our organization problem if he has the time concept sensu PIAGET. As our youngest subjects are eleven years old, we can assume that they all have the concept of time. Neglecting time limits would be due to a lower socialization level concerning integration of time concept into the concept of labour.

(3) Simultaneously or somewhat later a general economic principle is internalized. A general feature of our culture is the comprehension of 'time' as a measure for labour. The amount of labour is usually expressed in units of time, for example the number of hours which were worked. Therefore time itself becomes the dominant criterion for planning and action. The lesser amount of time necessary to finish a task increases the profit involved. This social and economic norm is popularly verbalized as "time is money". In our organization problem we would expect that a person who has internalized this norm will prefer a solution which needs the least amount of time.

The assumptions made above summarize well known results of research in development and socialization under specific topics. The following hypotheses concerning developmental changes in problem solving can be proposed.

Hypotheses

(1) Sequences with places (tasks) of high valence at an early position are more often found in younger groups than in older ones (see level (3) and (4) concerning the internalization of the concept of labour).

(2) Solutions using the bicycle are more often found in older groups, solutions with walking all the routes appear more often in younger groups (see level (5) concerning internalization of the concept of labour and and level (3) concerning the integration of the concept of time into the concept of labour).

(3) Having the book brought is more often found in older groups, immediate personal activities appear more often in younger ones (see level (6) concerning the internalization of the concept of labour).

(4) Time limits are more often regarded in older groups than in younger ones.

(5) The principle of time economy is more often used by older subjects. They prefer solutions in which the time for performing the task is minimized (see level (3) of integration of time concept into the concept of labour).

Results

The first hypothesis (sequence according valence order) could only be proved for one place: the play-ground. Its time limits lie approximately in the middle of the whole time line and there is an occasion to come earlier to the play-ground than necessary. As it is shown in table 4, there was a tendency for younger subjects to arrive earlier at the play-ground and to do other things later. The average rank of the adults must be understood as a result of their strategy to minimize effort and time span. Therefore they ranked the play-ground higher than the fourteen-year-olds.

Table 4. Differences in ranking the playground within the solution sequence

age	11	14	adults
average rank of play-ground	2,87	3,44	2,32
	$p \leq 0.025$ (MANN-WHITNEY)		

Assumption (2) was also confirmed as it is shown in table 5. The main change seems to occur between the group of fourteen-year-olds and the adults.

Table 5. Walking vs. using the bicycle as elements of the solution at different ages

age	11	14	adults
riding on bicycle	12 (27)	20 (44)	12 (71)
walking	33 (73)	25 (56)	5 (29)
total	45 (100)	45 (100)	17 (100)

Per cent in brackets

$\chi^2 = 6.15$ s. ($p < .05$)

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The third assumption about having the book brought refers to the last level of socialization. We should therefore assume that this level will appear later. As it is seen in table 6, the strategy of waiting until the friend brings the book is rarely found in the younger groups whereas nearly all adults use it.

Table 6. Fetching the book vs. having the book brought as elements of the solution at different ages.

age	11	14	adults
fetching the book	45 (100)	39 (87)	5 (29)
having the book brought	0 (0)	6 (13)	12 (71)
total	45 (100)	45 (100)	17 (100)

Per cent in brackets

comparison 14/adults:

$\chi^2 = 19{,}18$ s. ($p < .001$)

The results concerning the fourth hypothesis are yet discussed earlier (table 3). It could not be decided whether the increase in 'correct' solutions is due to the development of formal capacity in problem solving or to the internalization of the social norm of time concept. According to previous results in cognitive developmental research all subjects of our sample must have the time concept, therefore it is justified to assume that special conditions of socialization determine partially this result.

The last hypothesis concerning economy of time interfers with the task element of using the bicycle as a machine or a tool. As all adults except five had bicycle solutions, the absolute amount of time spent for performing the tasks did not supply new information. Therefore only bicycle solutions were compared.

As it is seen in table 7, older subjects spent less time in completing the routes than younger ones. The observed differences seem to confirm our assumption about increasing time economy with ongoing age.

Table 7. Average amount of time in minutes needed for completing routes at different ages.

age	11	13	adults
bicycle solutions and combined solutions	87,00	68,50	45,08
n	6	12	12

only 'correct' solutions are included

$p < .05$ (KRUSKAL-WALLIS)

A cross-validity experiment

The results reported above seem to confirm theoretical assumptions about the influence of level of general socialization on actual problem solving behavior. But there is the danger of a vicious circle: the results suggest theoretical issues and these are confirmed by the results. Our arguing remains an immanent process.

In order to leave this circle we have to do a further step. Remember our assumption that general socialization, especially the internalization of the concept of labour, determines the level of problem solving behavior in the organization task. This means that a problem of the same complexity and structure but without the social context would be much more difficult for socialized person. On the contrary less socialized individuals would possibly have less difficulty with a problem structure which is purified from the social context.

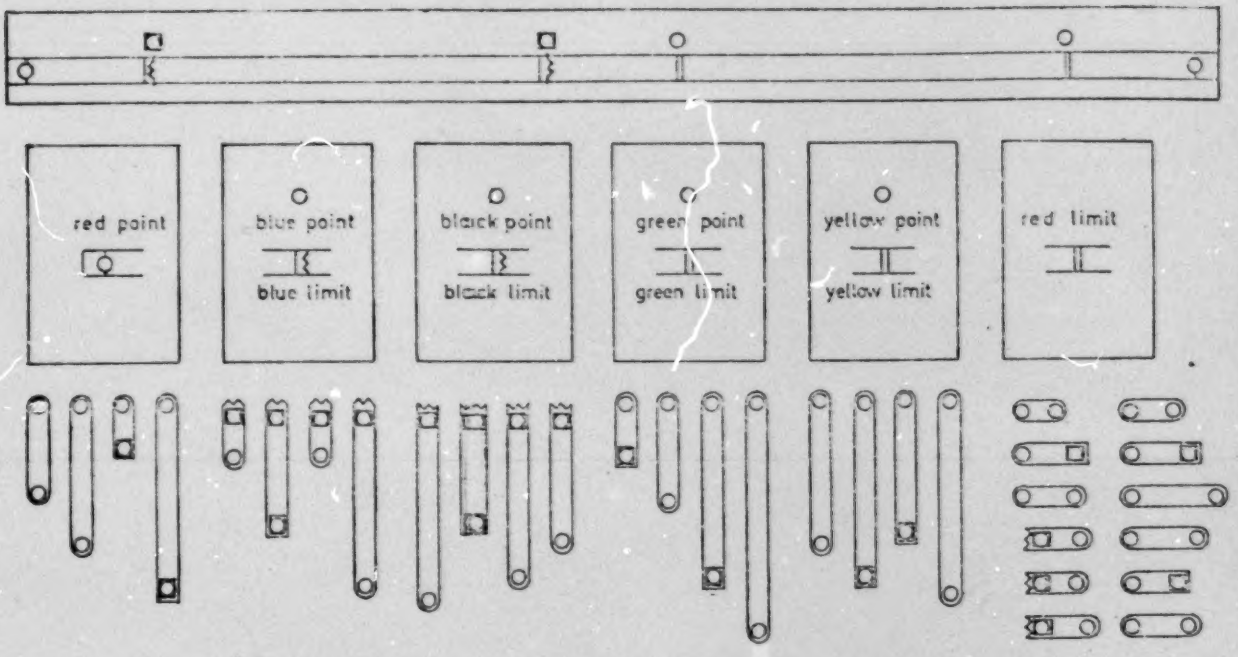
In other words, the rules of the organization problem are meaningful for socialized persons if the problem is embedded in a social context. On the other hand the problem becomes ambiguous or meaningless for adults if the rules are extracted from the social context.

It was therefore constructed a new problem with nearly the same structure as the organization problem. A full identity of structure could not be restored but the main elements of the organization task were included.

Materials.

The organization problem was transformed into a so-called Domino-Game (figure 6). The whole time distance from 12.30 to 6 o'clock p. m. was represented as a long band on which the subject has to place single stripes. They represented all possible routes between the places. The stripes were ordered in correspondence to the places where the routes began. The bicycle condition was represented as stripes with one third length. Marks of different colors on the time band indicated the time limits to be observed. For the subject the task consisted in laying stripes on the long band whereby several rules had to be observed.
The rules corresponded with the time limits given in the organization task. In effect, each type of stripe had to be ordered on the band without transgressing given demarcations.
The condition of having the book brought could not be introduced. So the structure of the domino-task was a little less complex than the structure of the organization task.

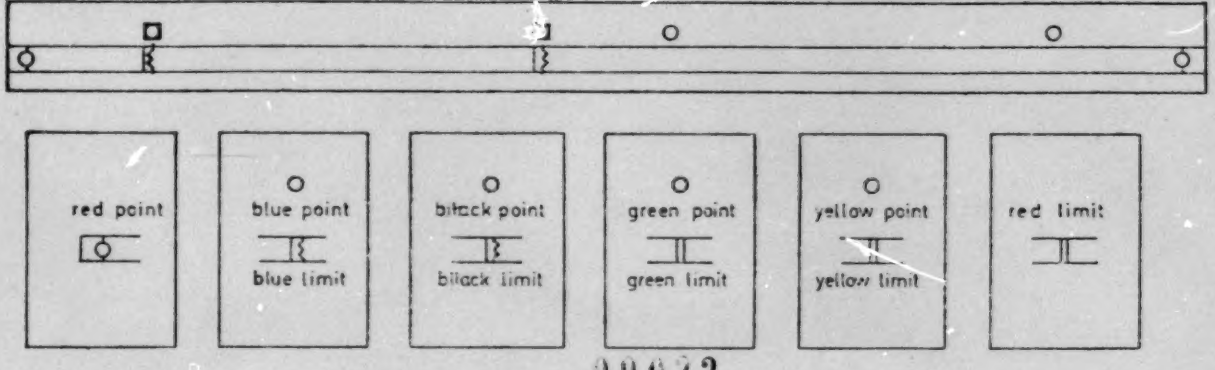
Figure 6. Domino-task: materials



Subjects and procedure.

15 eleven-year-olds, 15 fourteen-year-olds and 15 adults (university-students) were individually run. The material was presented as it is shown in figure 7. The subject was asked to play a game similar to domino. The rules were printed on cards which lay covered below the band with the corresponding stripes laying under them. All activities, especially lifting up the cards, were recorded on a special diagram which cannot be described here.

Figure 7. Domino-task: presentation



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Hypotheses.

It was predicted that adults had more difficulty in solving the domino-task than in solving the organization task. Nevertheless it could be expected that all adult persons would solve the problem. So the time needed for finding a solution was taken as a measure of task difficulty.

On the other hand it could be predicted that younger subjects would perform better in the domino-task than in the organization problem because they are less socialized with regard to the concept of labour. As younger subjects only partially performed 'correct' solutions in the organization-task, we expected not only that the time spent for solving the domino-task would be shorter but also that the number of correct solutions would be larger.

Results.

As it is seen in table 8, there was an interaction between time and type of problem. Adults needed more time for solving the domino-task whereas younger groups spent more time in solving the organization task.

A second result can be seen in the number of correct solutions. The youngest group produced more correct solutions on the domino-task than on the organization-problem ($p \leq .01$).

Table 8. Age differences in task-performance of the organization problem and the domino-task

age		11	14	adults
average solution time in minutes	organization problem	18 n = 45	15 n = 45	5 n = 17
	domino-task	6 n = 15	11 n = 15	13 n = 15

age		11	14	adults
per cent of 'correct' solutions	organization problem	29 n = 45	51 n = 45	100 n = 17
	domino-task	67 n = 15	53 n = 15	80 n = 15

Concluding remarks.

The preliminary studies presented here offer some evidence that cognitive development results from a strong interaction between the contents of the social world and its structural components. It is probably misleading to study content variables and structural variables separately.

If we regard cognitive development as a process embedded in socialization as a whole, we are forced to analyse objective structures of individual's environment together with its content variables. Similar to the correspondence of objective and subjective structure in the region of physical principles, we may expect an increasing correspondence of objective and subjective structure in the complex area of social life during the ongoing socialization process.

Therefore it seems necessary to analyse more carefully objective structures of our social world. Moreover descriptions of objective structures already presented in other disciplines such as sociology and economics should be used.

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SUMMARY

A particular task was constructed in order to study problem solving behavior necessary in complex social situations. The complex structure of the task was seen as representative for some characteristics of every-day life.
Problem solving behavior of three groups of age was compared. Developmental changes were first described in terms of pure formal processes of thinking. On the other hand the results confirmed the assumption that internalization of the concept of labour is a condition for regarding relevant elements of the task. In a cross-validity-study performance in solving a problem of the same structure but without the social context was examined. While adults performed better in the task embedded in a social context, the juveniles had less difficulties in the task without the social context.
The results seem to confirm the general assumption that cognitive development must be understood not only as building up formal structures but also as internalization of relevant concepts of culture and society.

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